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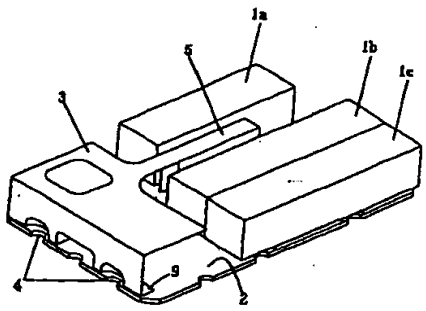
(54) Dielectric resonator device, dielectric duplexer, and communication apparatus incorporating same

(57) The invention discloses a compact dielectric resonator device that can prevent deterioration of the filter characteristics of the device due to the size reduction of a metal cover. In this dielectric resonator device, a plurality of dielectric coaxial resonators (1a, 1b, 1c) is mounted on a substrate. The metal cover (3) is arranged in such a manner as to cover only the open faces of the dielectric coaxial resonators (1a-1c), on which terminals electrically connected to inner conductors of the dielectric coaxial resonators (1a-1c) are led out. In addition, protrusions (5) of the metal cover (3) are electrically connected to specified parts between the adjacent dielectric coaxial resonators (1a, 1b).

Fig. 7



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to dielectric resonator devices, dielectric duplexers, and communication apparatuses incorporating the same, which are used in mobile communication equipment such as cellular phones.

2. Description of the Related Art

[0002] Conventionally, as shown in Fig. 13, a dielectric filter formed by coupling a plurality of individual dielectric coaxial resonators has a structure, in which a plurality of dielectric coaxial resonators 1a to 1h is mounted on the upper surface of a substrate 2, to which a metal cover is attached to cover the substrate 2 and the plurality of dielectric coaxial resonators 1a to 1h so as to electrically connect the metal cover 3 to grounding electrodes 4 on the substrate 2. This figure shows a view obtained by seeing through the metal cover 3.

[0003] However, with a demand for miniaturization of the mobile communication equipment, in order to make the dielectric filter having the above structure smaller, it is necessary to reduce the thickness of the metal cover. As a device which can solve the problem, Japanese Unexamined Patent Application Publication No. 7-235805 discloses a resonator device in which the upper surfaces of dielectric coaxial resonators are exposed while the other parts thereof are covered by a metal cover.

[0004] Nevertheless, the structure in which only the coupling parts of the dielectric coaxial resonators are covered by the metal cover causes a problem. There are some parts in which the paths of ground currents flowing from outer conductors of the dielectric coaxial resonators to the grounding electrodes on the substrate tend to be longer. Therefore, unless the metal cover are electrically connected to the outer conductors of the dielectric coaxial resonators without fail, the filter characteristics of the device can be deteriorated.

SUMMARY OF THE INVENTION

[0005] Accordingly, it is an object of the present invention to provide a dielectric resonator device, a dielectric duplexer, and a communication apparatus incorporating the same, which can achieve miniaturization of the devices and prevent the deterioration of filter characteristics caused by a reduction in the size of a metal cover.

[0006] According to a first aspect of the present invention, there is provided a dielectric resonator device including a plurality of dielectric coaxial resonators having outer conductors and inner conductors, a substrate having the plurality of dielectric coaxial resonators disposed thereon, and a metal cover connected to grounding electrodes of the substrate. In this dielectric resonator device, one specified dielectric coaxial resonator of the plurality of dielectric coaxial resonators is separated from the adjacent dielectric coaxial resonator by a specified gap, the metal member does not cover the upper surfaces of the plurality of dielectric coaxial resonators, and a part of the metal member allows the outer conductors of the dielectric coaxial resonators to be electrically connected to each other in the specified gap.

[0007] With this arrangement, the short path of a ground current is generated from each of the side surfaces of specified dielectric coaxial resonators to each of the grounding electrodes of the substrate via the metal cover.

[0008] In addition, the metal member may cover at least one of an area close to open-circuited faces of the dielectric coaxial resonators and an area where terminals electrically connected to the inner conductors of the dielectric coaxial resonators are led out.

[0009] The part of the metal member may be bonded to the outer conductors of the dielectric coaxial resonators by a conductive bonding agent in the specified gap.

[0010] In addition, the grounding electrodes may be formed near the part of the metal member that may be flexible.

[0011] Furthermore, the metal member may be formed by a metal plate, and the part of the metal member may be subjected to bending. With this arrangement, rigidity of the part of the metal member is increased, and areas where the part of the metal member is bonded to the outer conductors of the dielectric coaxial resonators are also increased.

[0012] Furthermore, the part of the metal member may be subjected to ribbing. This increases the rigidity of the part of the metal member and can also improve bonding reliability. Or, alternatively, a punched hole may be formed in the part of the metal member. With this arrangement, like the case of ribbing, bonding reliability can be improved.

[0013] According to a second aspect of the invention, there is provided a dielectric duplexer including the dielectric resonator device described above, and a transmission filter and a reception filter formed by the plurality of dielectric coaxial resonators used in the dielectric resonator device. In this dielectric duplexer, the dielectric coaxial resonators of the transmission filter are separated from the adjacent dielectric coaxial resonators of the reception filter by the specified gap.

[0014] According to a third aspect of the present invention, there is provided a communication apparatus including one of the dielectric resonator device and the dielectric duplexer described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a perspective view of the appearance showing the structure of a dielectric duplexer according to a first embodiment of the present invention;
Fig. 2 is a perspective view of the appearance of a metal cover used in the above dielectric duplexer;
Fig. 3 is a circuit diagram of the above dielectric duplexer;
Fig. 4 is a perspective view of the appearance showing the structure of a dielectric filter according to a second embodiment of the present invention;
Fig. 5 is a perspective view of the appearance of a metal cover used in the above dielectric filter;
Fig. 6 is a circuit diagram of the above dielectric filter;
Fig. 7 is a perspective view of the appearance showing the structure of a dielectric duplexer according to a third embodiment of the present invention;
Fig. 8 is a perspective view of the appearance of a metal cover used in the dielectric duplexer;
Fig. 9 is a perspective view of the appearance of a metal cover having another structure;
Fig. 10 is a perspective view of the appearance of a metal cover having another structure;
Fig. 11 is a perspective view of the appearance of a metal cover having another structure;
Fig. 12 is a perspective view of the appearance of a metal cover having another structure; and
Fig. 13 is a perspective view showing the structure of a conventional dielectric duplexer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Referring to Figs. 1 to 3, a description will be given of the structure of a dielectric duplexer according to a first embodiment of the present invention.

[0017] Fig. 1 is a perspective view of the appearance of a dielectric duplexer. Fig. 2 is a perspective view of the appearance of only a metal cover used in the above dielectric duplexer. In Fig. 1, reference numerals 1a, 1b, 1c, 1d, 1e, and 1f denote dielectric coaxial resonators having outer conductors formed on the outer surfaces of rectangular-parallelepiped dielectric members. Through-holes are formed in the central axes of the dielectric members, and inner conductors are formed on the inner surfaces of the through-holes. In a direction shown in Fig. 1, on the right back end faces of the dielectric coaxial resonators, the outer conductors are formed to be short-circuited, and on the left front end faces thereof, no outer conductors are formed to be open-circuited. Pin terminals electrically connected to the inner conductor are inserted in the through-holes of the dielectric coaxial resonators 1a to 1f. The outer conductors of the dielectric coaxial resonators 1a to 1f are bonded to grounding electrodes 4 disposed on the upper surfaces of a substrate 2 by using a conductive boding agent such as solder. Reference numeral 3 denotes a metal cover. As also shown in Fig. 2, the metal cover 3 is formed by stamping and bending a metal plate. The metal cover 3 has protrusions 5 protruding in the axial directions of the dielectric coaxial resonators and conductive side portions 6 electrically connected to side surfaces of the outermost dielectric coaxial resonators of the aligned dielectric coaxial resonators formed in a state in which the metal cover 3 is bonded to the substrate 2. In addition, at a plurality of spots on the metal cover 3 are formed grounding terminals 9 connected to the grounding electrodes 4 of the substrate 2 and projections 10 for determining a position with respect to the substrate 2.

[0018] In the state shown in Fig. 1, the grounding terminals 9 of the metal cover 3 are soldered to the grounding electrodes 4 on the substrate 2. In addition, the protrusions 5 of the metal cover 3 are interposed between the dielectric coaxial resonators 1a and 1b and between the dielectric coaxial resonators 1b and 1c, and the outer conductors of the mutually adjacent dielectric coaxial resonators 1a, 1b, and 1c are bonded to each other by using a conductive bonding agent such as solder. Since the protrusions 5 of the metal cover 3 are subjected to bending, rigidity of the protrusions 5 is increased particularly in a direction parallel to the substrate 2. As a result, even when the widths of the protrusions 5 are narrowed, since the deformation of the protrusions 5 can be prevented, the protrusions 5 can be reliably connected to the outer conductors of the dielectric coaxial resonators.

[0019] In addition, as shown in Fig. 2, in the metal cover 3, since the grounding terminals 9 are disposed near the protrusions 5 and the conductive side portions 6, the path of a ground current flowing from the outer conductor of each of the dielectric coaxial resonators to each of the grounding electrodes on the substrate can be shortened.

[0020] The positioning projections 10 disposed on the metal cover 3 are inserted in the holes of the substrate 2 to set the position of the metal cover 3 with respect to the substrate 2. Furthermore, when the dielectric coaxial resonators 1a to 1f are disposed on the substrate with the metal cover 3 by soldering, since the positioning of the dielectric coaxial resonators 1a to 1f is performed by the protrusions 5 of the metal cover 3 and the conductive side portions 6, the positional relationships between the substrate 2, the metal cover 3, and the dielectric coaxial resonators 1a to 1f can be easily maintained fixed. As a result, in mass production of the dielectric resonator devices, stable filter characteristics can be obtained.

[0021] In addition, by using flexibility of the metal cover 3, when arrangement is made such that the pro-

trusions 5 and the conductive side portions 6 abut with the outer conductors of specified dielectric coaxial resonators, the outer conductors of the dielectric coaxial resonators can be electrically connected to the metal cover without soldering.

[0022] Fig. 3 shows the circuit diagram of the dielectric duplexer. Reference numerals Ra to Rf denote resonators corresponding to the dielectric coaxial resonators 1a to 1f shown in Fig. 1. The resonators Ra and Rb are disposed between a transmitted-signal input port Tx and an antenna port ANT via capacitors and inductors having specified electrical lengths. The resonators Rc to Rf, which are connected in sequence via capacitors, are disposed between the antenna port ANT and a received-signal output port Rx.

[0023] The above arrangement forms a transmission filter constituted of the two resonators Ra and Rb, which has band-blocking-type filter characteristics, and a reception filter constituted of the four resonators Rc to Rf, which has band-pass-type filter characteristics.

[0024] In this way, since the dielectric coaxial resonators 1a and 1b shown in Fig. 1 form the transmission filter handling a relatively large amount of electric power, when ground connection is performed without fail by the protrusions 5 and the conductive side portions 6 of the metal cover 3, deterioration of the attenuation characteristics caused by detouring of the ground-current path can be prevented. In addition, the protrusions 5 of the metal cover 3 are electrically connected between the dielectric coaxial resonator 1b as the last-stage resonator of the transmission filter and the dielectric coaxial resonator 1c as the first-stage resonator of the reception filter. With this arrangement, entering of a transmitted signal into the reception filter caused by detouring of the ground current can also be prevented without fail.

[0025] Next, referring to Figs. 4 to 6, a description will be given of the structure of a dielectric filter according to a second embodiment of the present invention.

[0026] Fig. 4 is a perspective view of the appearance of the dielectric filter, and Fig. 5 is a perspective view of the appearance of only a metal cover of the dielectric filter. In Fig. 4, reference numerals 1a, 1b, and 1c denote the same dielectric coaxial resonators as those used in the first embodiment. Outer conductors of the dielectric coaxial resonators 1a to 1c are bonded to grounding electrodes on the upper surface of a substrate 2 by using a conductive bonding agent. Reference numeral 3 denotes a metal cover. As also shown in Fig. 5, the metal cover 3 is formed by stamping and bending a metal plate. In a state in which the metal cover is bonded to the substrate 2, the metal cover 3 has protrusions 5 protruding in the axial direction of the dielectric coaxial resonators and the conductive side portions 6 electrically connected to the side surfaces of the outermost dielectric coaxial resonators of the aligned dielectric coaxial resonators. In addition, on a plurality of places of the metal cover 3 are formed grounding terminals 9 connected to the grounding electrodes of the substrate 2 and projections 10 for setting the position of the metal cover 3 with respect to the substrate 2.

[0027] As shown in Fig. 4, the grounding terminals 9 of the metal cover 3 are soldered to the grounding electrodes 4 on the substrate 2. The protrusions 5 of the metal cover 3 are interposed between the dielectric coaxial resonators 1a and 1b and between the dielectric coaxial resonators 1b and 1c, and the outer conductors of the mutually adjacent dielectric coaxial resonators 1a, 1b, and 1c are bonded to each other by a conductive bonding agent such as solder. As shown in Fig. 5, on the metal cover 3, since the grounding terminals 9 are disposed near the protrusions 5 and the conductive side portions 6, the paths of ground currents flowing from the outer conductors of the dielectric coaxial resonators 1a, 1b, and 1c to the grounding electrodes 4 on the substrate 2 can be shortened. The other effects and advantages in the second embodiment are the same as those obtained in the first embodiment.

[0028] Fig. 6 shows a circuit diagram of the above dielectric filter. Reference numerals Ra to Rc denote resonators corresponding to the dielectric coaxial resonators 1a and 1c shown in Fig. 4. The resonators Ra to Rc, which are connected in sequence via capacitors, are disposed between an input port IN and an output port OUT.

[0029] The above arrangement forms a dielectric filter constituted of the resonators Ra to Rc of three stages, which has band-pass-type filter characteristics.

[0030] Next, referring to Figs. 7 and 8, a description will be given of the structure of a dielectric duplexer according to a third embodiment of the present invention.

[0031] Fig. 7 is a perspective view of the appearance of the dielectric filter, and Fig. 8 is a perspective view of the appearance of only a metal cover of the dielectric filter. In Fig. 7, reference numerals 1a, 1b, and 1c denote the same dielectric coaxial resonators as those used in the first embodiment. Outer conductors of the dielectric coaxial resonators 1a to 1c are bonded to grounding electrodes 4 on the upper surface of a substrate 2 by using a conductive bonding agent such as solder. Reference numeral 3 denotes a metal cover. As also shown in Fig. 8, the metal cover is formed by stamping and bending a metal plate. In a state in which the metal cover 3 is bonded to the substrate 2, the metal cover 3 has protrusions 5 protruding in the axial direction of the dielectric coaxial resonators and grounding terminals 9 connected to the grounding electrodes 4 of the substrate 2.

[0032] In the state shown in Fig. 7, the grounding terminals 9 of the metal cover 3 are soldered to the grounding electrodes 4 on the substrate 2. The protrusions 5 of the metal cover 3 are interposed between the dielectric coaxial resonators 1a and 1b, and the outer conductors of the mutually adjacent dielectric coaxial

resonators 1a and 1b are bonded to each other by a conductive bonding agent such as solder. With this arrangement, the paths of ground currents flowing from the outer conductors of the dielectric coaxial resonators to the grounding electrodes 4 on the substrate can be shortened.

[0033] In Fig. 7, the dielectric coaxial resonator 1a serves as a trap resonator for a transmission filter. The dielectric coaxial resonators 1b and 1c serve as the two-stage resonator of a reception filter.

[0034] As shown in Fig. 8, the protrusion 5 of the metal cover 3 is subjected to bending and has two surfaces parallel to the mutually opposing outer surfaces of the dielectric coaxial resonators 1a and 1b. In this way, by bending the protrusion 5 of the metal cover 3, rigidity of the protrusion 5 is increased and the deformation thereof is thereby prevented. As a result, positional accuracy between the metal cover 3 and the plurality of dielectric coaxial resonators can be improved. Moreover, the areas in which the protrusion 5 is bonded to the outer conductors of the dielectric coaxial resonators can be increased, so that ground connection can be more reliably performed.

[0035] Next, Referring to Figs. 9 to 12, a description will be given of the examples of protrusions of the metal cover having different configurations.

[0036] In an example shown in Fig. 9, a protrusion 5 of a metal cover 3 is subjected to bending. Unlike the example shown in Fig. 8, only one side of the protrusion 5 is subjected to bending. Thus, the protrusion 5 has a surface along the outer surface of one of the adjacent two dielectric coaxial resonators. With this configuration, rigidity of the protrusion 5 can be improved, and also bending can be facilitated.

[0037] In an example shown in Fig. 10, a protrusion 5 of a metal cover 3 is subjected to bending, and a rib 7 is formed in the protrusion 5 by ribbing. With this configuration, rigidity of the protrusion 5 can be more increased. In addition, since the rib 7 serves as a groove for guiding the flow of solder between the metal cover 3 and side surfaces of the dielectric coaxial resonators, bonding when soldered can also be enhanced.

[0038] In an example shown in Fig. 11, a punched hole 8 is formed in a protrusion 5 of a metal cover 3, and the protrusion 5 is subjected to bending. In this way, when the punched hole 8 is formed, the punched hole 8 serves as a groove for guiding the flow of solder between the metal cover 3 and the side surfaces of the dielectric coaxial resonators. Thus, soldering strength can be increased as in the case of ribbing.

[0039] In an example shown in Fig. 12, although a protrusion 5 of a metal cover 3 is subjected to bending, the surface along the outer surfaces of the dielectric coaxial resonators is not formed. Instead, the protrusion 5 is bent into a V-letter form or a reversed V-letter form. In this arrangement, an area for the used metal plate can be reduced, and deformation due to bending is also small. Thus, forming processing of the protrusion 5 can be facilitated.

[0040] As described above, in the dielectric resonator device of the present invention, the shortened path of a ground current is generated from the side surfaces of specified dielectric coaxial resonators to the grounding electrodes on the substrate via the metal cover. Thus, deterioration of filter characteristics associated with the miniaturization of the metal cover can be prevented.

[0041] In addition, according to an aspect of the invention, rigidity of the protrusion of the metal cover can be increased, and the area where the protrusion of the metal cover is bonded to the outer conductors of the dielectric coaxial resonators can be expanded. As a result, a more reliable ground connection can be implemented.

[0042] According to another aspect of the invention, rigidity of the protrusion of the metal cover and conductivity between the protrusion of the metal cover and the outer conductors of the adjacent two dielectric coaxial resonators can be provided. Moreover, forming of the protrusion can be facilitated.

[0043] According to another aspect of the invention, even when the width of the protrusion is made narrower, the strength of the protrusion can be maintained. Moreover, since the rib serves as a groove for guiding the in-flow of the conductive bonding agent such as solder, bonding strength and conductivity can be enhanced.

[0044] According to another aspect of the invention, since the punched hole serves as a groove for guiding the in-flow of the conductive bonding agent such as solder, bonding strength and conductivity can be enhanced.

[0045] According to another aspect of the invention, the ground connection of the last-stage resonator of the transmission filter and the first-stage resonator of the reception filter can be performed without fail. Therefore, entering of a transmitted signal to the reception filter and entering of a received signal to the transmission filter can be reliably prevented. As a result, specified characteristics as a duplexer can be obtained.

[0046] Furthermore, according to another aspect of the invention, the communication apparatus obtained in the invention is overall compact and has communication performance capabilities using specified filter characteristics.

[0047] While the present invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details can be made therein without departing from the spirit and scope of the invention.

Claims

1. A dielectric resonator device comprising:

a plurality of dielectric coaxial resonators (1a-

1f; 1a-1c) having outer conductors and inner conductors;
a substrate (2) having the plurality of dielectric coaxial resonators (1a-1f; 1a-1c) disposed thereon; and
a metal member (3) connected to grounding electrodes (4) of the substrate (2);
wherein one specified dielectric coaxial resonator (1a, 1b; 1a) of the plurality of dielectric coaxial resonators (1a-1f; 1a-1c) is separated from the adjacent dielectric coaxial resonator by a specified gap;
the metal member (3) does not cover the upper surfaces of the plurality of dielectric coaxial resonators (1a-1f; 1a-1c); and
a part of the metal member (3) allows the outer conductors of the dielectric coaxial resonators (1a-1f; 1a-1c) to be electrically connected to each other in the specified gap.

2. A dielectric resonator device according to Claim 1, wherein the metal member (3) covers at least one of an area close to open-circuited faces of the dielectric coaxial resonators (1a-1f; 1a-1c) and an area where terminals electrically connected to the inner conductors of the dielectric coaxial resonators (1a-1f; 1a-1c) are led out.

3. A dielectric resonator device according to Claim 1 or 2, wherein the part of the metal member (3) is bonded to the outer conductors of the dielectric coaxial resonators (1a-1f; 1a-1c) by a conductive bonding agent in the specified gap.

4. A dielectric resonator device according to any of Claims 1-3, wherein the grounding electrodes (4) are formed near the part of the metal member (3).

5. A dielectric resonator device according to any of Claims 1-4, wherein the part of the metal member (3) is flexible.

6. A dielectric resonator device according to any of Claims 1-5, wherein the metal member (3) is formed by a metal plate, and the part of the metal member (3) is subjected to bending.

7. A dielectric resonator device according to any of Claims 1-6, wherein the metal member (3) is formed by a metal plate, and the part of the metal member (3) is subjected to ribbing.

8. A dielectric resonant device according to any of Claims 1-7, wherein the metal member (3) is formed by a metal plate, and a punched hole (8) is formed in the part of the metal member.

9. A dielectric duplexer comprising:
the dielectric resonator device according to one of Claims 1 to 8; and
a transmission filter and a reception filter formed by the plurality of dielectric coaxial resonators (1a-1f; 1a-1c) used in the dielectric resonator device;
wherein the dielectric coaxial resonators (1a, 1b; 1a) of the transmission filter are separated from the adjacent dielectric coaxial resonators (1c-1f; 1b, 1c) of the reception filter by the specified gap.

10. A communication apparatus comprising the dielectric resonator device according to one of Claims 1 to 8.

11. A communication apparatus comprising the dielectric duplexer according to Claim 9.

Fig. 1

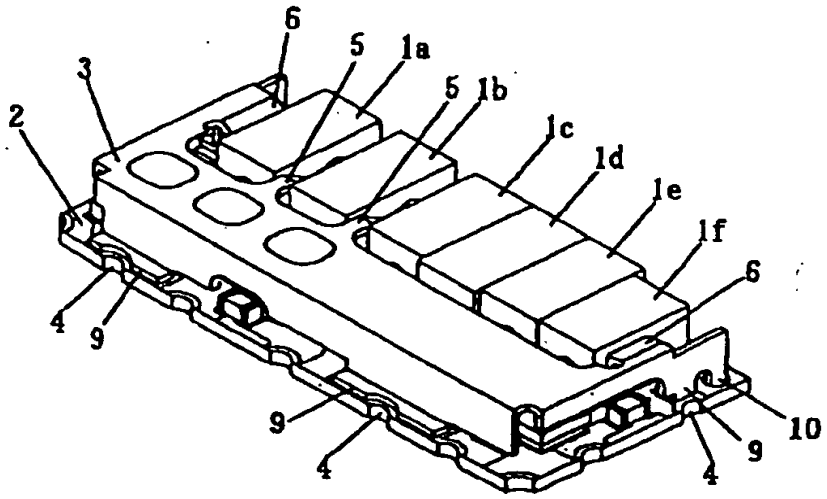


Fig. 2

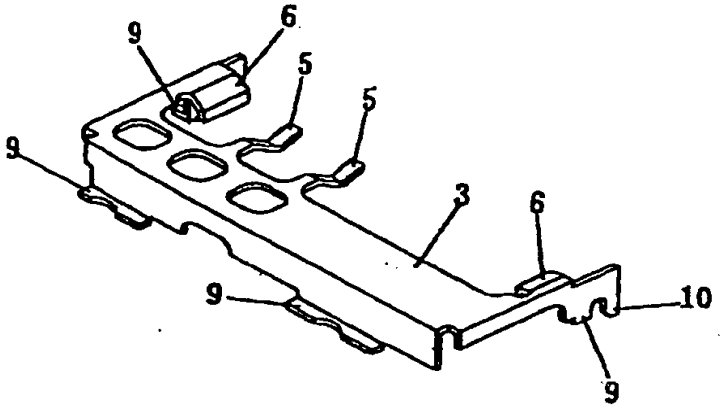


Fig. 3

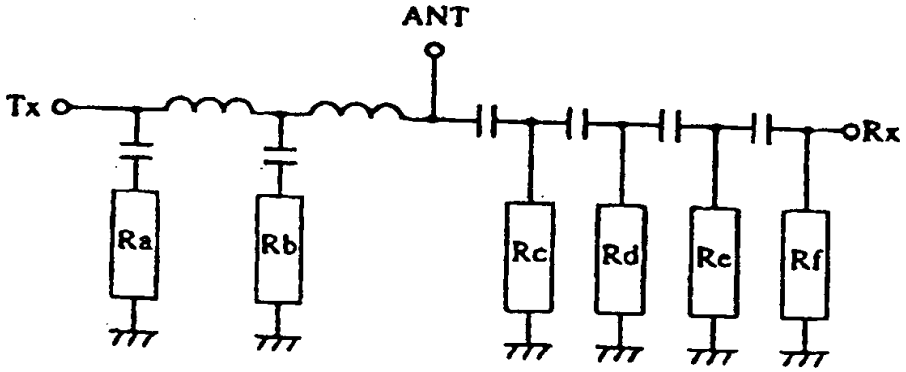


Fig. 4

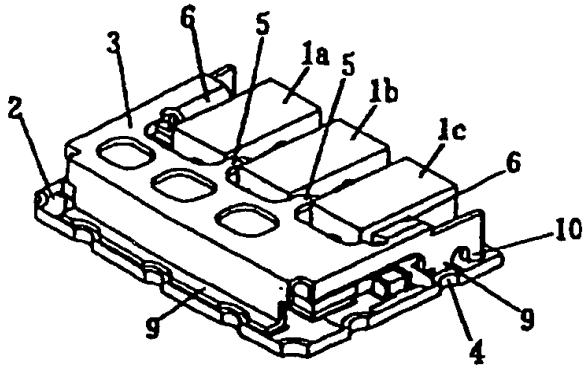


Fig. 5

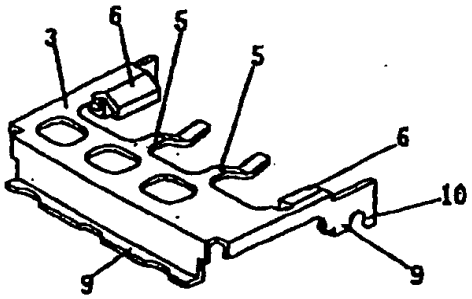


Fig. 6

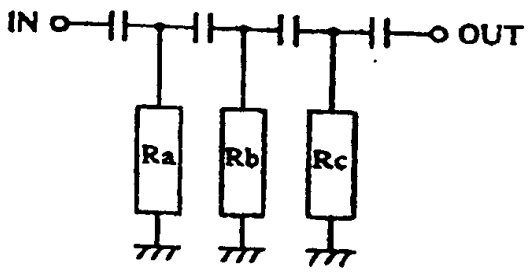


Fig. 7

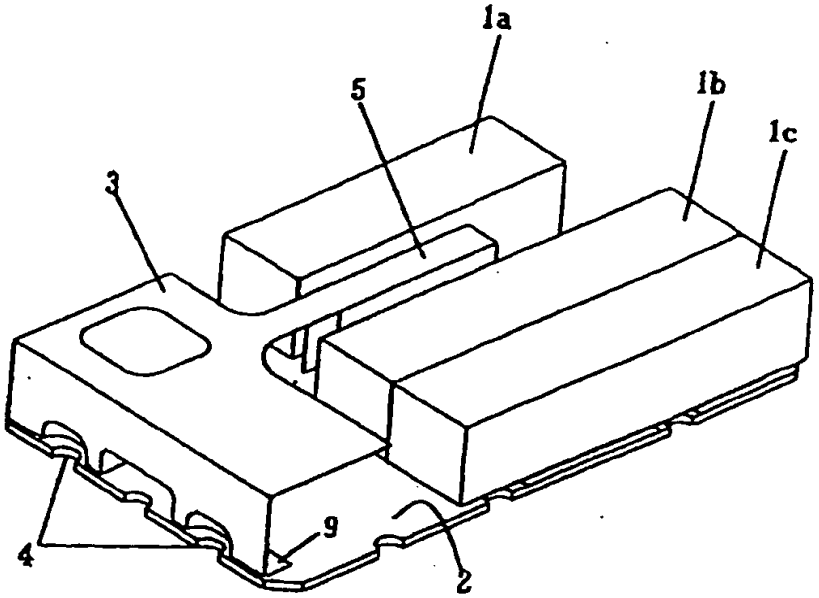


Fig. 8

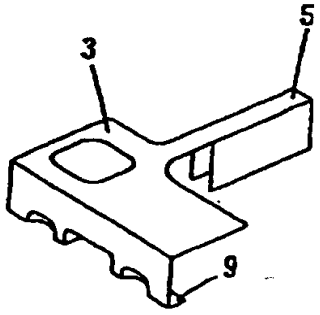


Fig. 9

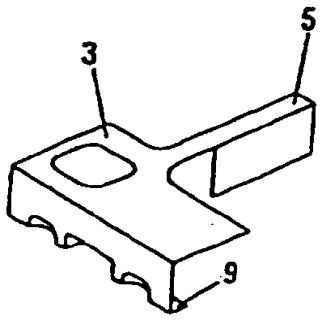


Fig. 10

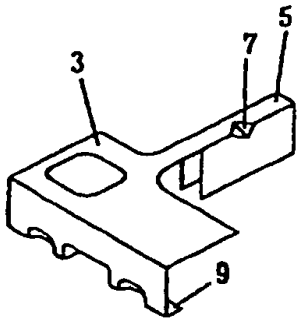


Fig. 11

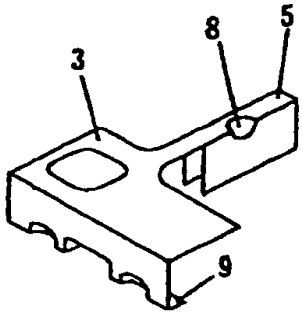


Fig. 12

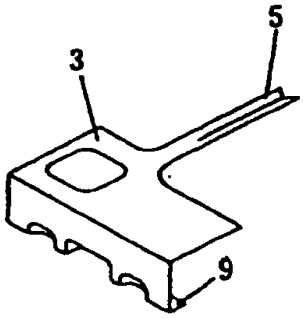
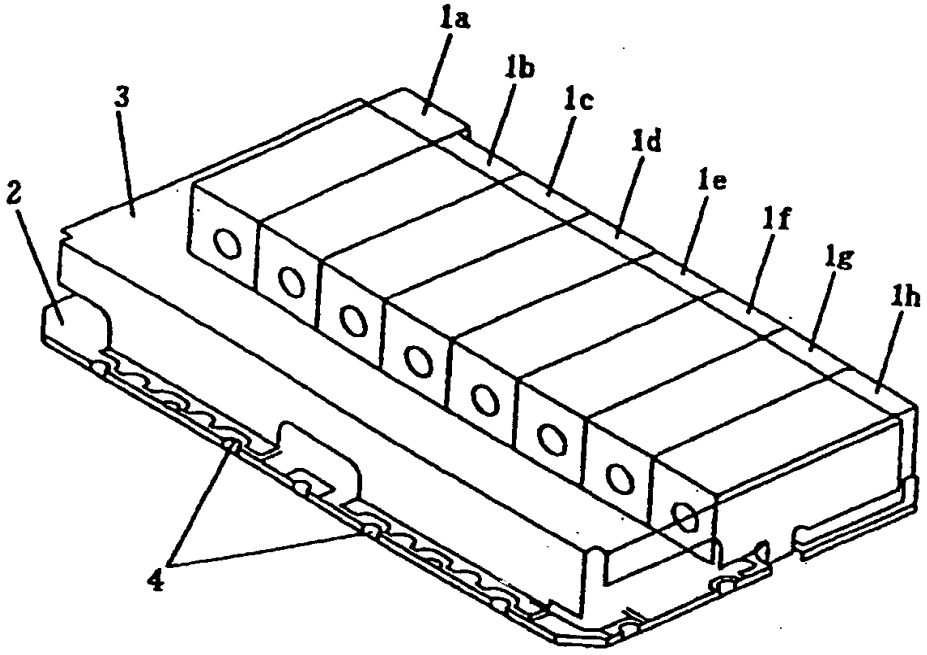


Fig. 13



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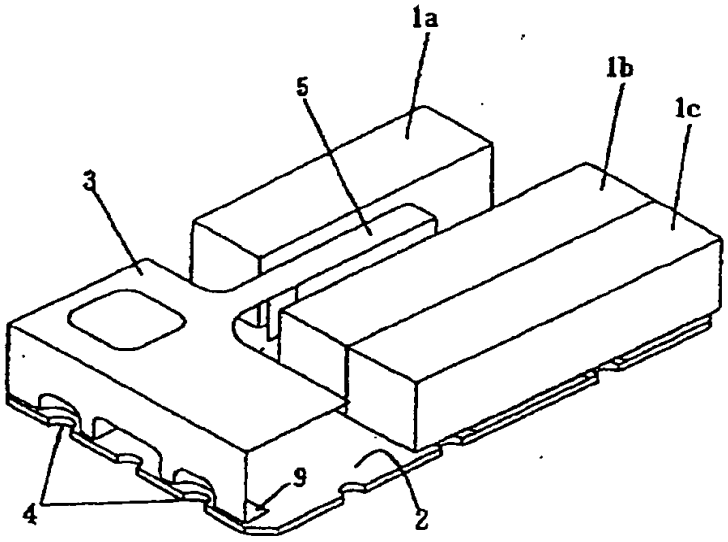
(54) Dielectric resonator device, dielectric duplexer, and communication apparatus incorporating same

(57) The invention discloses a compact dielectric resonator device that can prevent deterioration of the filter characteristics of the device due to the size reduction of a metal cover. In this dielectric resonator device, a plurality of dielectric coaxial resonators (1a, 1b, 1c) is mounted on a substrate. The metal cover (3) is arranged in such a manner as to cover only the open faces of the dielectric coaxial resonators (1a-1c), on which terminals electrically connected to inner conductors of the dielectric coaxial resonators (1a-1c) are led out. In addition, protrusions (5) of the metal cover (3) are electrically connected to specified parts between the adjacent dielectric coaxial resonators (1a, 1b).

Fig. 7



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Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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